Pathophysiology of Systolic and Diastolic Heart Failure

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KEYWORDS

• Chronic heart failure • Systolic heart failure • Diastolic heart failure

KEY POINTS

- Systolic and diastolic heart failure are the 2 most common clinical subsets of chronic heart failure.
- Left ventricular "Starling" function is depressed in patients with systolic heart failure.
- In systolic heart failure, left ventricular mass is increased, which can be measured by transthoracic echocardiography. Cardiac magnetic resonance imaging is a more precise technique to measure left ventricular mass.
- Neurohormonal activation is a major pathophysiologic mechanism for ventricular remodeling and progression of heart failure in systolic heart failure.

HISTORICAL PERSPECTIVES

The differences between systolic and diastolic heart failure have been recognized for several decades. In 1937, Dr Fishberg described that diastolic heart failure results from inadequate ventricular filling, and he termed this type of heart failure as hypodiastolic failure. He also recognized that systolic heart failure results from inadequate emptying of the heart and he called it hyposystolic failure.[1]

Definitions

The most commonly used definition of systolic heart failure is that "it is a pathophysiologic state in which an abnormality of cardiac function is responsible for the failure of the heart to pump blood at a rate commensurate with the requirements of the metabolizing tissues."[2] However, such a definition , although precise, is difficult to use in clinical practice. The definition of systolic heart failure that is used clinically is that it is "a syndrome which results from reduced left ventricular ejection fraction."[3] Systolic heart failure is also termed "heart failure with reduced ejection fraction" (HFREF). The pathophysiologic definition of diastolic heart failure is that "it is a condition resulting from an increased resistance to filling of one or both ventricles leading to symptoms of

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congestion due to an inappropriate shift of the diastolic-pressure volume relation (that is during the terminal phase of the cardiac cycle."[4]

The clinical definition of diastolic heart failure is that "it is a clinical syndrome characterized by the symptoms and signs of heart failure, a preserved left ventricular ejection fraction and abnormal diastolic function."[5] Diastolic heart failure is also termed "heart failure with preserved ejection fraction" (HFPEF). In this review, the terms systolic and diastolic heart failures are used instead of HFREF and HFPEF.

Pathophysiology

In systolic heart failure, the left ventricle is dilated and there is increase in both left ventricular end-diastolic and end-systolic volumes; but, as there is a greater increase in end-systolic than in end-diastolic volume, left ventricular ejection fraction is reduced. Ejection fraction is the ratio of left ventricular total stroke volume and its end-diastolic volume. Thus, when there is a disproportionate increase in end diastolic volume, ejection fraction may decline and the stroke volume may remain normal (**Fig. 1**A). Left ventricular stroke volume is the difference between end-diastolic and end-systolic volume. In some patients, when there is a disproportionate decrease in stroke volume, ejection fraction may decline despite normal left ventricular end-diastolic volume (see **Fig. 1**B).

There are substantial changes in the shape of the left ventricle. Normally, the left ventricle is ellipsoidal. In systolic heart failure, it becomes spherical. Changes to globular shape cause misalignment of the papillary muscles, chordate, and mitral valve leaflets, which is associated with mitral regurgitation. Mitral regurgitation causes further increase in left ventricular volumes and progressive remodeling.

In systolic heart failure, the left ventricular wall thickness remains unchanged or may decrease. The normal or decreased left ventricular wall thickness along with an increase in ventricular volumes is associated with increased wall stress (**Fig. 2**). There is an inverse relationship between wall stress and ejection fraction. The higher the wall stress, the lower is the ejection fraction. Thus, in patients with systolic heart failure, an increase in wall stress contributes to decreased ejection fraction. The major mechanism of reduced ejection fraction, however, is decreased contractility. The morphologic and functional changes in systolic heart failure are summarized in **Table 1**.

Left ventricular "Starling" function is depressed in patients with systolic heart failure. Ventricular "Starling" function is the relationship between its stroke volume

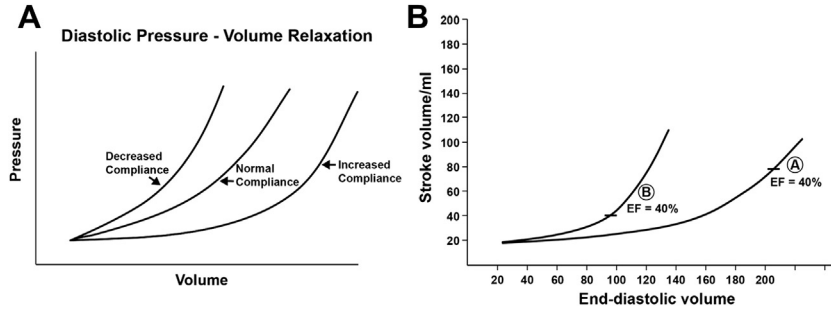

Fig. 1. Schematic illustrations of pressure (*vertical axis*) and volume (*horizontal axis*). When there is a disproportionate increase in end-diastolic volume, ejection fraction can be reduced with normal stroke volume (*A*). Ejection fraction may decrease to the same extent when there is a disproportionate decrease in stroke volume with normal end-diastolic volume (*B*).